6. (Amended) The electrode of claim 1 wherein the insert comprises a first ring-shaped member comprising a high thermionic emissivity material disposed in a ring-shaped bore of a second [ring-shaped] member formed of a high thermal conductivity material.

10. (Amended) An electrode for a plasma arc torch, the electrode comprising:

an elongated electrode body formed of a high thermal conductivity material and having a bore disposed in a bottom end of the electrode body; and

an insert disposed in the bore and comprising a composite structure comprising a high thermionic emissivity material dispersed within a high thermal conductivity material, the [and a] high thermionic emissivity material comprising hafnium or zirconium.

18. (Amended) A method of manufacturing an electrode for a plasma arc torch comprising:

a) providing an elongated electrode body formed of a high thermal conductivity material;

b) forming a bore at a bottom end of the elongated electrode body relative to a central axis through the electrode body; and

c) inserting a ring-shaped insert comprising a high thermionic emissivity material in the bore, the high thermionic emissivity material comprising hafnium or zirconium.

29. (Amended) A method of manufacturing an electrode for a plasma arc cutting torch, comprising:

a) providing an elongated electrode body formed of a high thermal conductivity material;

b) forming a bore at a bottom end of the elongated electrode body relative to a central axis extending longitudinally through the electrode body;

c) forming an insert comprising a composite structure comprising a high thermionic emissivity material dispersed within a high thermal conductivity material, the [and a] high thermionic emissivity material comprising hafnium or zirconium; and

d) inserting in the bore of the electrode body.

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34. (New) A plasma arc torch comprising:

a torch body;

a nozzle supported by the torch body, the nozzle having an exit orifice; and

an electrode supported by the torch body in a spaced relationship from the nozzle, the electrode comprising an elongated electrode body formed of a high thermal conductivity material and having a bore disposed in a bottom end of the electrode body and a ring-shaped insert comprising a high thermionic emissivity material disposed in the bore.

35. (New) The torch of claim 34 wherein the high thermionic emissivity material comprises hafnium or zirconium.

36. (New) The torch of claim 34 wherein the insert comprises a first ring-shaped member formed of a high thermionic emissivity material and a second cylindrical member formed of a high thermal conductivity material disposed in the first ring-shaped member.

37. (New) The torch of claim 34 wherein the insert comprises a first ring-shaped member comprising a high thermionic emissivity material disposed in a ring-shaped bore of a second member formed of a high thermal conductivity material.

38. (New) The torch of claim 34 wherein the insert further comprises a high thermal conductivity material.

39. (New) A plasma arc torch comprising:

a torch body;

a nozzle supported by the torch body, the nozzle having an exit orifice; and

an electrode supported by the torch body in a spaced relationship from the nozzle, the electrode comprising an elongated electrode body formed of a high thermal conductivity material and having a bore disposed in a bottom end of the electrode body and an insert comprising a composite structure disposed in the bore, the composite structure comprising a high thermionic emissivity material dispersed within a high thermal conductivity material.

40. (New) The torch of claim 39 wherein the high thermionic emissivity material comprises hafnium or zirconium. --

RESPONSE

Changes to the Claims

Claims 1, 6, 10, 18, and 29 have been amended. Claims 3 and 11 have been canceled, without prejudice. New claims 34-40 have been added. Support for all claim amendments are found in the originally-filed application. No new matter has been added.

Rejection of Claims 1, 2, 4-10, 12, 13, 15, and 16 under § 102

Claims 1, 2, 4-10, 12, 13, 15, and 16 are rejected under 35 U.S. C. 102(b) as being anticipated by U.S. Patent No. 3,592,994 to Ford ("Ford").

Applicants' invention is directed to an electrode for use in a plasma arc torch which has an insert configuration for providing an improved service life of the electrode. A traditional electrode has an electrode body having a bore at the bottom end of the body, and a cylindrical insert formed of a high thermionic emissivity material, such as tungsten, hafnium, or zirconium, placed in the bore. The size of the emitting surface of the cylindrical insert is increased for higher current capacity operations. The high thermionic emissivity insert, however, has poor thermal

conductivity relative to the electrode body, making removal of heat from the center of the insert to the surrounding electrode body difficult.

A known way to address this problem is to reduce the diameter of the insert. However, this method is inappropriate for a hafnium or zirconium insert which has a lower boiling point than tungsten. When the torch operates at a high current, the temperature of the hafnium or zirconium insert can exceed their boiling point, causing rapid loss of the insert material. Applicants have discovered a new insert configuration for an electrode which facilitates heat removal without sacrificing electrode life.

Amended claim 1 is directed to an electrode for a plasma arc torch. The electrode comprises an elongated electrode body and a ring-shaped insert. The electrode body is formed of a high thermal conductivity material and has a bore disposed in a bottom end of the electrode body. The ring-shaped insert comprises a high thermionic emissivity material disposed in the bore. The high thermionic emissivity material comprises hafnium or zirconium.

Amended claim 10 is directed to an electrode for a plasma arc torch. The electrode comprises an elongated electrode body and an insert. The electrode body is formed of a high thermal conductivity material and has a bore disposed in a bottom end of the electrode body. The insert is disposed in the bore. The insert comprises a composite structure comprising a high thermionic emissivity material dispersed within a high thermal conductivity material. The high thermionic emissivity material comprises hafnium or zirconium.

Ford describes a spot-welding electrode. The electrode has a tip with a flat operative contact face and an annular recess surrounding the contact face. An annular insert is force fit into the recess. The insert is formed of a conductive material having greater strength and resistance to deformation under welding conditions than the material forming the contact face. The insert is made of tungsten or molybdenum or their alloys.

Ford does not teach or suggest an electrode for a plasma arc torch. Ford also does not teach an electrode comprising a hafnium or zirconium insert. Ford describes a spot welding electrode, which is fundamentally different from an electrode for a plasma arc torch. In spot welding, two sheets of metal are clamped between a pair of electrodes, and a heavy current is passed from one electrode to the other, thereby heating the sheets and welding the sheets as the sheets are cooled. Ford teaches that a spot-welding electrode should have "good thermal and electrical conductances and that, in use, it should be resistant to deformation." Therefore, Ford recommends using materials such as tungsten and molybdenum, which have high melting point (i.e., 3410°C and 2617°C). Hafnium and zirconium, on the other hand, would not be suitable as the insert material for Ford's spot-welding electrode, because these materials are more susceptible to deformation due to their lower melting point (i.e., 2227°C and 1852°C).

Therefore, applicants submit that amended claims 1 and 10, and their dependent claims 2, 4-9, 12, 13, 15, and 16 are patentable over Ford.

Rejection of Claims 1-33 under 35 U.S.C. § 103

Claims 1-33 are rejected under 35 U.S.C. § 103(a) as being unpatentable over either U.S. Patent No. 5,451,739 to Nemchinsky et al. ("Nemchinsky") or U.S. Patent No. 5,097,111 to Severance, Jr. ("Severance") in view of Ford.

Nemchinsky and Severance both describe an electrode for a plasma arc torch. The electrode has an insert consisting of a high-emissive material surrounded with a sleeve composed of a non-emissive material. Examples of high-emissive material include hafnium, zirconium, and tungsten. Examples of non-emissive material include silver, gold, platinum, rhodium, iridium, palladium, and nickel. The sleeve discourages arc from transferring from the insert to the sleeve and/or holder (i.e., electrode body).

Nemchinsky and Severance do not teach or suggest an electrode comprising a ring-shaped insert comprising a high thermionic emissivity material as recited in amended claim 1.

Nemchinsky and Severance, in fact, teach the opposite, since Nemchinsky and Severance teach a ring shaped insert comprising a low thermionic emissivity material.

Nemchinsky, Severance, and Ford, individually or in combination, do not teach or suggest the invention recited in amended claim 1. Applicants further submit that there is no teaching, suggestion, or motivation to combine the teachings of Nemchinsky or Severance with the teachings of Ford. Nemchinsky and Severance describe a plasma arc torch for cutting or piercing a work piece. Ford describes spot welding, which is unrelated to plasma arc cutting or piercing. In addition, the problem addressed by Nemchinsky and Severance is unrelated to the problem addressed by Ford. Nemchinsky and Severance describe preventing the transfer of arc from the insert of the electrode to the body of the electrode by surrounding a high-emissive material with a low-emissive material. Ford, on the other hand, describes preventing mushrooming of the electrode by providing a ring-shaped insert material having great strength and resistance to deformation during welding. Moreover, none of the references describe enhancing heat removal, a problem addressed by the applicants' invention.

Ford describes a ring-shaped tungsten insert, whereas Nemchinsky and Severance describe a solid, cylindrical hafnium, zirconium, or tungsten insert. However, one of ordinary skill in the art of plasma arc cutting and piercing reviewing Nemchinsky, Severance, and Ford would have no reason to change the cylindrical hafnium, zirconium, or tungsten insert of Nemchinsky and Severance to a ring-shaped insert of Ford. Therefore, amended claim 1 and claims depending therefrom are believed to be patentable over the cited references.

Applicants further submit that none of the cited references teaches or suggests an insert comprising a composite structure comprising a high thermionic emissivity material dispersed within a high thermal conductivity material, where the high thermionic emissivity material comprises hafnium or zirconium, as recited in amended claim 10. Nemchinsky and Severance do not teach or suggest an insert comprising a composite structure. Ford does not teach or suggest

an insert comprising hafnium or zirconium. Therefore, applicants submit that amended claim 10 and claims depending therefrom are patentable over the cited references.

New Claims 34-40

New claim 34 recites a plasma arc torch. The torch comprises a torch body, a nozzle supported by the torch body, and an electrode supported by the torch body in a spaced relationship from the nozzle. The nozzle has an exit orifice. The electrode comprises an elongated electrode body formed of a high thermal conductivity material and having a bore disposed in a bottom end of the electrode body. A ring-shaped insert comprising a high thermionic emissivity material is disposed in the bore.

New claim 39 also recites a plasma arc torch. The torch comprises a torch body, a nozzle supported by the torch body, and an electrode supported by the torch body in a spaced relationship from the nozzle. The nozzle has an exit orifice. The electrode comprises an elongated electrode body formed of a high thermal conductivity material and having a bore disposed in a bottom end of the electrode body. An insert comprising a composite structure of a high thermionic emissivity material dispersed within a high thermal conductivity material is disposed in the bore.

Ford does not teach or suggest a plasma arc torch. Nemchinsky and Severance do not teach or suggest a plasma arc torch comprising an electrode having a ring-shaped insert comprising a high thermionic emissivity material. Nemchinsky and Severance also do not teach or suggest a plasma arc torch comprising an electrode having a insert comprising a composite structure of a high thermionic emissivity material dispersed within a high thermal conductivity material.

Therefore, applicants submit that new claims 34 and 39 and claims depending therefore are patentable over Nemchinsky, Severance and Ford.